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Managing technological distance in internal and external collaborations: absorptive capacity routines and social integration for innovation

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Abstract While high technological distance to project partners outside of the established value chain can positively influence innovation performance, project goals can only be achieved if the social integration of project members is improved in terms of coordination and communication. This paper draws on embeddedness and absorptive capacity literature to explore how social integration mechanisms translate into different learning outcomes in distant collaborations within and across organizational boundaries. Drawing upon expert interviews with project members as our primary source of data, we conducted an in-depth multiple case study analysis of a number of inter-organizational projects. Our findings indicate that the effect of different types of social integration mechanisms on learning outcomes also affect the ability to bridge distances in process and product technology. Moreover, they suggest that it is not just the extent, but also the interplay of social integration mechanisms surrounding internal and external absorptive capacity routines that enable project members to engage in the exploration, transformation and exploitation of distant knowledge. In examining how social integration mechanisms foster learning outcome in distant collaborations, our study contributes to the literature on absorptive capacity.

Keywords Innovation · Collaboration · Technological distance · Knowledge transfer · Social integration · Absorptive capacity

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1 Introduction

The innovation process involves a resource-intensive search aimed at exploring new frontiers which are radically different from existing offerings to find commercially-exploitable new combinations of technological knowledge (Laursen 2012; Rosenkopf and Nerkar 2001). Hence organizations need to work with and draw on knowledge from a multitude of actors, both within and outside of their organization (Katila and Ahuja 2002). A key aspect of the innovation process frequently described in previous papers, is the exploitation of both internal and external knowledge sources to develop and commercialize innovation to prevent an unacceptably narrow internal focus (Love et al. 2014).

Firms do not just look outside their own organizations' boundaries, but beyond their primary industry to acquire new and external knowledge because they recognize the value of potential partners who are outside the established value chain. Partnerships may be the result of informal collaborations, strategic alliances or joint ventures. They provide opportunities to diversify knowledge about new technologies and innovations (Datta and Jessup 2013; Rosenkopf and Almeida 2003; Rosenkopf and Nerkar 2001). By seeking innovation from outside of their own industry, firms extend their scope to acquire technologies different from those currently in their portfolio and to increase the number and variety of possible new technological combinations with potential for highly innovative solutions (Fleming 2001). Technological distance is therefore a reflection of the "extent that firms differ in their technological knowledge and expertise" (Gilsing et al. 2008, p.1719).

High technological distance makes it more likely that organizations will encounter potentially valuable internal and external partners during collaboration.[1] These encounters increase the novelty and value of knowledge that is exchanged, which in turn leads to radical innovation (Enkel and Heil 2014). However, at a certain point, technological distance becomes so high that it precludes the mutual understanding required to utilize the knowledge and opportunities created by collaboration (Gilsing et la. 2008; Nooteboom et al. 2007; Wuyts et al. 2005). To cope with high technological distance, it is crucial for organizations to avoid an inconclusive exchange of knowledge when it ventures beyond its core industry to ensure successful explorative learning and knowledge creation (Ahuja and Morris Lampert 2001). In this vein, it is beneficial to foster personal interaction with the collaborating partner as this can promote the sharing of distant knowledge and reduce many of the costs of integration (Katila and Ahuja 2002) and recombinatory innovation (Phelps 2010). In particular, absorptive capacity literature (e.g., Cohen and Levinthal 1990; Lewin et al. 2011; Todorova and Durisin 2007, Zahra and George 2002) has pointed to the importance of social integration and interaction when external knowledge has to be absorbed, i.e. acquired, assimilated, transformed and explored (ibid). Different mechanisms of social integration have been found to transcend internal and external absorptive capacity routines and to facilitate coordination and communication within and between collaborating organizations (Ebers and Maurer 2014; Hotho et al. 2012; Lewin, Massini and Peeters 2011; Todorova and Durisin 2007; Zahra and George 2002). Jansen et al.

[1] In that context, internal partners refers to different project teams or team members within the same organization but not involved in the focal project or innovation activity itself and external partners refers to any team or actor outside the focal organization that is included or addressed during collaboration.

(2005) empirically demonstrated that absorptive capacity is strengthened by social integration mechanisms such as connectedness to internal knowledge sources at different hierarchical levels and the socialization tactics of individuals in organizations. At the same time, Ebers and Maurer (2014) showed how the external and internal connectedness of an organization's boundary spanners respectively affect the organization's potential and realized absorptive capacity. This is consistent with other literature emphasizing how an organization's connectedness to external knowledge sources provides benefits in terms of access to and exploitation of external knowledge (Cockburn and Henderson 1998; Zucker et al. 1994; Zucker et al. 2002, 1998), and innovation performance (Owen-Smith and Powell 2004; Powell et al. 1996). Furthermore, literature points to the role of social proximity to partners in organizations' ability to learn and innovate by interaction (Granovetter 1985, Uzzi 1997). Accordingly, strong social connections facilitate the integration of difficult-to-transfer knowledge. Further, and of particular importance with respect to collaboration with partners of high technological or cognitive distance (Nooteboom et al. 2007), i.e. distant collaboration, strong connections and embeddedness are believed to provide alternative solutions when it comes to coordinating and communicating private and proprietary knowledge. More specifically, such alternative ways of coordinating and communicating proprietary knowledge can increase team productivity and facilitate explorative learning (Reagans and McEvily 2003; Uzzi and Lancaster 2003).

In other words, organizations that aim to exchange knowledge of high technological distance with external or internal partners in order to innovate can benefit from a variety of social integration mechanisms. Social integration enables the organization to recognize and understand external knowledge, assimilate and recombine it with existing knowledge, and also apply the new knowledge created, i.e. it enables its capacity to absorb external knowledge. Associated mechanisms range from connectedness and internal as well as external partners, social interaction with partners to communication and socialization.

While the introduced literature emphasizes the importance of social integration in absorbing external knowledge related to an organization's knowledge base, it does not provide empirical evidence on how different mechanisms of social integration from lower-level actors, such as single project team members or project assistants, enrich an organization's ability to fully integrate distant knowledge and innovate. It also remains unclear, how and to what extent social integration mechanisms can facilitate external knowledge absorption and of an organization and its learning capabilities (Nooteboom et al. 2007). Accordingly, Volberda et al. (2010) suggested further research regarding this matter to explore the complementarity between the development of absorptive capacity for intra- and inter-organizational antecedents enabling social integration. In a similar vein, researchers are calling for an investigation (e.g., Bartsch et al. 2013; Ebers and Maurer 2014) on the importance and interplay between different mechanisms of social integration, e.g., connectedness or socialization that affect an organization's absorptive capacity. This is why we intend to address the following research question: How do social integration mechanisms facilitate learning in collaboration with partners from within or outside the organization when dealing with high technological distance?

A qualitative analysis of 26 projects in the German manufacturing sector illustrates that there are four social integration mechanism types which, individually or combined, influence an organization's ability to absorb distant knowledge in a relevant innovation project. Furthermore, our results suggest that it is not necessarily the extent, but especially the diversity and interplay between social integration mechanisms in the processing of external knowledge that enable comprehensive absorption. By differentiating between and elaborating on internal connectedness, external connectedness, systematic communication

and socialization as distinct social integration mechanisms, this study contributes to reification of the concept of absorptive capacity (Cohen and Levinthal 1990; Hotho et al. 2012; Jansen et al. 2005; Lane et al. 2006; Lewin et al. 2011; Volberda et al. 2010; Zahra and George 2002).

2 Theoretical framework

2.1 Technological distance and absorptive capacity

As set forward by Schumpeter (1939), the creation of new knowledge is the result of recombining existing knowledge. Accordingly, our research investigated technological distance as a barrier for collaborative innovation from a knowledge perspective. At the same time, variety and resource heterogeneity are a valuable source of inter-organizational learning and potentially provide new knowledge (Ahuja 2000; Leyden et al. 2014; Phelps 2010; Powell et al. 1996; Rosenkopf and Almeida 2003; Wuyts et al. 2005). Originating from the concept of cognitive distance (Nooteboom 2000; Nooteboom et al. 2007), technological distance can be considered a "translation" of the concept of cognitive distance from the organizational level to the technological level. Accordingly, technological distance refers to the differences between collaborating organizations' technological experience and knowledge bases. Technological distance specifically exists between the collaborating project team members (i.e., lower-level actors) at the level of process technology which mediates between inputs and outputs, and at the level of product technology which creates new products or services (Knoben and Oerlemans 2006).

The general influence and importance of optimal technological distance during collaboration with regard to knowledge absorption and innovation (Nooteboom 1992; 1999) has been empirically demonstrated by a number of studies (Gilsing et al. 2008; Nooteboom et al. 2007; Wuyts et al. 2005). Those studies have established an inverted U-shaped relationship between the concept of cognitive distance and collaboration success (ibid.). Respectively, the relationship between technological distance and innovation is both, a blessing and a curse. On the one hand, as technological distance increases between collaboration partners, the novelty of knowledge exchange increases resulting in radical innovation (e.g., Ahuja and Morris Lampert 2001; Phene et al. 2006). On the other hand, as technological distance increases, understanding between collaboration partners decreases and knowledge exchange becomes more complex and, at a certain point, is no longer possible between the collaborating partners. If partners' technological knowledge bases are too similar though, collaboration entails only low levels of novelty value resulting in incremental innovation. This may be the result of technological lock-in where similar knowledge bases limit the development of new technologies or new market possibilities as there is little left to learn (Boschma 2005; Knoben and Oerlemans 2006).

It has been shown that the determining factor in overcoming the risks of technological distance in order to benefit from its opportunities is an organization's absorptive capacity (Bröring and Leker 2007; Gilsing et al. 2008; Nooteboom et al. 2007; Wuyts et al. 2005). In other words, highly developed absorptive capacity strengthens the ability of organizations to collaborate for innovation at a high technological distance (Lewin et al. 2011; Todorova and Durisin 2007; Zahra and George 2002). In the following, we will elaborate on the role of absorptive capacity in successfully collaborating with partners operating in a distant technological context and how social integration plays a distinct role. Absorptive capacity provides organizations with rich external knowledge and additional options for

problem solving, allowing them to engage in explorative innovation through rare combinations of existing knowledge (Jansen et al. 2006). While some overlap exists among the various conceptualizations of absorptive capacity (e.g., Cohen and Levinthal 1990; Lane et al. 2006; Todorova and Durisin 2007; Zahra and George 2002), a common conceptualization has yet to emerge and is a subject of current debate in the literature (Volberda et al. 2010). For the purposes of this study, we consolidated the process-based conceptualization of absorptive capacity of Lane et al. (2006) with the component capabilities of Todorova and Durisin (2007). This dynamic representation of absorptive capacity comprises three phases. First, potentially valuable new external knowledge needs to be recognized and understood (explorative learning). Second, the knowledge is assimilated and related to the firm's internal knowledge base and processes (transformative learning). Third, new knowledge is created and applied by recombining the assimilated knowledge with existing knowledge (exploitative learning) (Lane et al. 2006; Todorova and Durisin 2007). Furthermore, we refer to Lewin et al.'s (Lewin et al. 2011) framework of internal and external absorptive capacity routines. Internal absorptive capacity routines relate to the management of internal variation, selection and replication processes. External absorptive capacity routines, on the other hand, encompass the management of exploration to obtain new knowledge in the external environment (Lewin et al. 2011).

Combining the concept of technological distance with its potentials and challenges and the concept of absorptive capacity, an organization benefits from mechanisms that enable it to enhance absorptive capacity and to overcome technological distance when collaborating with partners for innovation (see Fig. 1). In this study, we therefore examine how social integration mechanisms affect the different components of absorptive capacity, both individually and collectively, while facilitating the exchange of knowledge at a high technological distance.

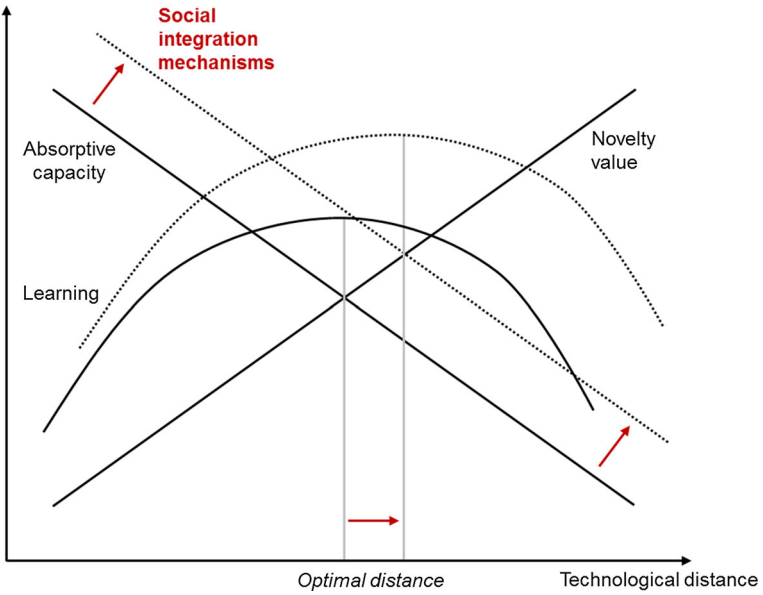

Fig. 1 Conceptualized implications of social integration mechanisms on capacity and technological distance. (Adapted from Nooteboom et al. 2007)

2.2 Social integration

The more diverse the knowledge base of a firm, the more accustomed its employees are to collaborating with individuals who have different areas of technological specialization (Schilling et al. 2003). The choice of individuals as unit of analysis within an organization and as members of collaborating project teams thus arises from social integration being repeatedly linked to underlying knowledge-related activities of individuals in the development of absorptive capacity and learning (Mowery et al. 1996; Schilling et al. 2003). Such activities occur both internally and externally and exhibit different process dimensions and components of absorptive capacity (Volberda et al. 2010). Subsequently, social integration mechanisms "enable the organization to share, communicate and transfer individual-level learning to the organizational level" (Lane et al. 2006, p. 846).

Social integration refers to the shared values, norms and other mechanisms that build connectedness (Jansen et al. 2005; Tsai and Ghoshal 1998; Walker et al. 1997) and socialization (Adler and Kwon 2002; Nahapiet and Ghoshal 1998) among members of an organization but also among collaborating partners that are not part of the same organization. It aids the collective development, sharing and integration of knowledge (Jaworski and Kohli 1993) from inside or outside of an organization (Lewin et al. 2011). It has been also demonstrated that mechanisms of social integration transcending internal and external absorptive capacity routines are especially beneficial in dealing with difficult-to-transfer knowledge (Uzzi and Lancaster 2003), and hence beneficial to the creation of innovation (Ebers and Maurer 2014; Gubbins and Dooley 2014). Social integration has been empirically found to enable individuals in different organizational units to process distant knowledge in a local context, despite these units having distinct knowledge bases (Hotho et al. 2012). Hotho et al. (2012) described social interaction as a prerequisite for absorptive capacity at the organizational level and demonstrated a positive connection between a unit's capacity to absorb and apply knowledge and the social interaction patterns within the unit. Similarly, it has been shown that internal relations establish social capital which is a prerequisite for knowledge sharing across intra-organizational boundaries (Bartsch et al. 2013; Maurer et al. 2011). However, mechanisms of social integration are not easy to observe or imitate (Lewin et al. 2011) and studies vary in the mechanisms investigated and their implications on knowledge transfer (e.g., Cohen and Levinthal 1990; Ebers and Maurer 2014; Hotho et al. 2012; Jansen et al. 2006; Lewin et al. 2011; Zucker et al. 1994).

For instance, connectedness refers to the overall pattern of organizations' social relations, meaning relations between members within the organization as well as social relations with members outside the organization (Jansen et al. 2006). It encourages communication and facilitates knowledge exchange within and between organizations (Jaworski and Kohli 1993; Sheremata 2000), allowing individuals with different experiences and knowledge to discuss and adopt new ideas (Hansen 2002), combine knowledge and develop new knowledge, which is the basis of explorative innovation (McFadyen and Cannella 2004). Connectedness also enables the adoption of explorative innovation and increases mutual understanding of goals and implementation (Rindfleisch and Moorman 2001; Subramaniam and Youndt 2005). Finally, Ebers and Maurer (2014) found that internal and external connectedness affects an organization's absorptive capacity which comprise complementary combinations and hence must be executed together. Moreover, as emphasized by Cockburn and Henderson (1998) and Zucker et al. (1994), "connectedness" to external knowledge sources increases awareness of what knowledge other organizations might need (Schulz 2003). This in turn helps organizations to recognize potentially

valuable external knowledge and transfer it back to the organization. Socialization, as another mechanism of social integration, fosters the establishment of social relations among individuals within and between organizations (Ashforth and Saks 1996) to further facilitate understanding and communication (Chao et al. 1994; Dingler and Enkel 2016). Thus, connectedness and socialization enhance the combination of newly acquired and existing knowledge from explorative, transformative and exploitative learning, develop an organization's absorptive capacity and increase the probability of collaboration success.

To summarize, if technological distance needs to be overcome, social integration may be a prerequisite for successful collaboration. In particular, as antecedents of absorptive capacity, social integration mechanisms are expected to facilitate collaboration between partners. As absorptive capacity and corresponding internal and external routines on their own do not provide an adequate foundation for collaborative innovation at high technological distance, we suggest that social integration mechanisms allow for greater degrees of knowledge exchange and learning, thus improving an organization's ability to collaborate with technologically distant partners. Moreover, as the absorptive capacity generated by an organization's internal routines influences its ability to use these routines with external knowledge sources, and vice versa, the organization can exploit the absorptive capacity provided by these routines more extensively. Therefore, we propose organizations with well-established social integration mechanisms benefit from complementary routines and, in similar vein, greater access to technological distant knowledge, which in turn enhances the absorptive capacity. In other words, social integration mechanisms as a set of independent variables influencing learning and learning from collaboration, thus, innovation performance of an organization as the dependent variable.

3 Methods

3.1 Research setting

We opted for a qualitative research design to address our research question of how social integration mechanisms facilitate collaborative learning over technological distance. Multiple case study research results were applied as there is only limited theory on what distinct role social integration mechanisms play for an organization's enhanced absorptive capacity as well as on how those specific mechanisms operate when technological distance has to be overcome (Eisenhardt 1989). There is currently only limited in-depth knowledge on this topic, so we have taken this opportunity to compare and contrast data because it will enable us to develop a richer and more valid theory (Strauss and Corbin 2008; Yin 2013). A multiple case study design was specifically chosen to closely examine the recurring patterns of social integration facilitating absorptive capacity in distant collaboration as there is a clear need for in-depth examination and causal inference, and "how" questions have to be asked of the subjects under study (Miles and Huberman 1994).

Following Ebers and Maurer (2014), we theoretically sampled projects in the German mechanical and plant engineering sector with comparable industry settings, environments and infrastructure to enhance the comparability of the cases (Eisenhardt and Graebner 2007). Project-based organizations typically need to develop absorptive capacity (Schwab 2009) to maintain their successful performance in the international market. They are forced to collaborate with other firms, communities and, in particular, universities in order to set their product offerings apart from those of international competitors with lower production

costs (ZEW 2011). We therefore choose the project-level to collect out data: these organizations provide a particularly conducive context for studying how the differences in social integration mechanisms affect the development of absorptive capacity while mainly acting on a project level. At the same time, projects teams are depending on their team members' actions and abilities (Schwab 2009). Hence, in the provided context projects represent organizations innovation ability on the one hand and the project teams on the social integration abilities of their individual team members (Ebers and Maurer 2014). In addition, as engineering projects in industry are often inter-organizational projects (Fong and Lung 2007), they provide an appropriate level of analysis for our study.

We focused on projects aimed at generating radical innovation concepts through the integration of partners from domains outside of the established value chain and technology from different industry backgrounds (Enkel and Gassmann 2010). As partners operating in the same industry are likely to have high levels of cognitive proximity on the basis of shared industry focus, experiences and understanding, we consider knowledge to be of little technological distance if it originates from within the inventor's industry, and distant if it originates from outside of that industry (Datta and Jessup 2013; Katila and Ahuja 2002; Li and Vanhaverbeke 2009).

To study how differences in social integration mechanisms lead to different learning outcomes, we study the organization in charge of a project. This was the organization responsible for coordinating and integrating new product development (NPD) with a major internal or external collaboration partner. To successfully absorb external knowledge and thus meet their specific project goals, project team members have to collaborate with external partners as well as employees from various business units within their organization (i.e., internal partners). This means, technological distance between team members arises on two sides: On the one side between the project team and its external partners that come from a different industry and on the other side between the project team and its internal partners that come from other business units with different industry backgrounds (Bresnen et al. 2003).

3.2 Sample data

With the support of the FVA (German Power Transmission Research Association), we distributed a questionnaire to its participating organizations with the aim of identifying representative NPD projects. The FVA represents about 200 member firms in the mechanical engineering and plant engineering sector and includes small and medium-sized enterprises (SME) as well as large firms, making it one of the largest and most important industrial associations in Germany. The questionnaire requested information about the project characteristics described above as well as the (1) key informant's position and function in the firm; (2) the industry in which the project was located; (3) the type of major collaboration partner (internal or external partner); (4) the components of the transferred process and product technology; and (5) the original industry domain of the respective process and product technology in the NPD process (Knoben and Oerlemans 2006). In addition, appropriate scales were adopted and included to allow respondents to subjectively measure innovation performance (Yao et al. 2013), the feasibility of technology transfer and the extent to which new and existing knowledge had been implemented at the process and product level (Ho and Ganesan 2013). The anchor points of the response scales ranged from 1 (strongly disagree) to 5 (strongly agree). The questionnaire used a technique suggested by Ragin (1992) to identify which project cases matched our empirical focus. This reduced the quantity of data and facilitated the collection of decisive evidence.

Between January and April 2014, we collected data from a subsample of 38 companies representative of the FVA's industry structure and operating under similar industry conditions (Eisenhardt and Graebner 2007). The resulting response rate of 19% is not unusual for mail surveys with business professionals (Shih and Fan 2008) because they often lack of time and refuse to take part in non-compulsory questionnaires (Paxson et al. 1995). Also, we only allowed firms' projects that closely matched the characteristics discussed above, i.e. they had obtained knowledge from a new partner operating at high technological distance (about three percent in total). The newly-acquired technological knowledge triggered NPD and hence was the primary reason for collaboration.

Of the 38 identified cases, twelve companies declined to participate in interviews due to company policy or a lack of time. Semi-structured interviews took place with the remaining 26 project cases from May to August 2014. These interviews were our primary data source. The case interviews were conducted as face-to-face interviews at the headquarters or subsidiaries, or via the telephone. The interviews lasted between 60 and 90 min, with most of them being taped and transcribed to ensure information reliability. To investigate the phenomenon from different perspectives and reduce single-respondent bias, we used multiple informants for each project, whenever possible. In cases, where only one informant could be approached, we aimed to avoid bias in retrospective reporting by interviewing those who were most knowledgeable about the corresponding project (Kumar et al. 1993). Our aim was to interview persons in sales and marketing with responsibility for the commercial development of the project ranging from the pre-offer phase to the end of the project, and R&D engineers responsible for the technological development. Additional validation of all interviews was provided by the respondents' final approval as well as on-site workshops with several members from each project. These workshops discussed the discrepancies and inconsistencies of the identified patterns which needed refinement during further analysis (Silverman 2013). Secondary data sources were analyzed to reduce the possibility of informal bias and eliminate the remaining possibility of single-informant bias (Eisenhardt and Graebner 2007; Yin 2013). The most commonly used archival documents were annual reports, press articles and releases, company websites, internal company documents (presentation slides, executive speeches, project reports, contractual agreements, product manuals and process descriptions) and industry reports obtained from the firms' Internet sites. We triangulated the data with the goal of increasing validity and substantiate findings (Gibbert et al. 2008). Specifically, for each case the available archival documents were checked in terms of content referring to the projects under investigation. Documents that included such references were included in the coding process described in the data analysis section.

The initial questions for the semi-structured interviews referred to the organizations' absorptive capacity routines comprising the three process phases which have been conceptually identified in the analytical framework previously outlined: explorative learning, transformative learning exploitative learning (Lane et al. 2006; Todorova and Durisin 2007). First, we examined whether and how each of these phases was executed by the focal organization in order to exchange and fully absorb the external and technologically distant knowledge. This part of the interview allowed for an analysis of the absorptive capacity routines included as well as the extent to which knowledge was ultimately absorbed and project goals were reached. A learning outcome was considered to be "successful" if the explored knowledge was transformed, exploited and retained in a new or changed practice. Conversely, learning was considered to be "limited" if the explored knowledge was not transformed, exploited *or* retained in a new or changed practice, or at least one of the predefined process phases of absorptive capacity routines was not reached. Second, we

examined whether the individual phases involved critical elements of distant knowledge transfer, how this caused managerial challenges in practice and whether and how those challenges could be met. For example, informants where asked about the way a certain barrier to transferring knowledge was resolved and, if there were social aspects involved, what those mechanisms where, how they operated, etc. In that section of the interview, we were able to differentiate between particular mechanisms and their distinct role in the three process phases of knowledge absorption. Our sample included both successful and unsuccessful projects, which enhanced the comparability of cases with regard to the differences in social integration mechanisms and the respective learning outcomes. Learning in distant collaboration was successfully managed in 17 cases. In the remaining 9 cases only limited learning was achieved. Table 1 provides an overview of the projects as well as the interviewees' position, the primary data sources and the respective target and distant source industry.

3.3 Data analysis

First, the interview and archival data was coded by two individual researchers (Miles and Huberman 1994; Strauss and Corbin 2008). This enabled us to identify how firms managed technological distance in innovation collaboration. The results of the coding process were then combined. With our theoretical framework comprising mainly literature on social integration mechanisms, we were able to inductively adjust the coding. Instead of considering technological distance in general terms, we realized that it would be more conducive to examine it at two of its sub-levels (Nooteboom et al. 2007), i.e. at the process technology level with respect to overcoming distance, and at the product technology level with respect to creating proximity. For the absorptive capacity process component, we worked with codes based on existing literature, categorizing the transfer of distant knowledge into the three phases of recognizing and understanding (explorative learning), assimilating (transformative learning), and recombining and applying (exploitative learning) external knowledge (Todorova and Durisin 2007; Lane et al. 2006). Furthermore, we distinguished between knowledge relating to distant product technology and knowledge relating to distant process technology. For example, statements on the personal involvement of IndustAuto's project team in a regularly meeting electrification work group for the duration of the corresponding project collaboration was coded as 'assimilating' and 'product technology.' The personal contacts with established external partners in order to discuss dimensions of cooperation in terms of industrializing external technology in the case of ConRace were coded as 'understanding' and 'process technology. Second, to facilitate meaningful intra- and cross-case analysis, an individual report was written for each case (Eisenhardt 1989; Yin 2013). Case reports based on coded interview data, corresponding transcriptions as well as the archival data included for triangulation proposes (Jick 1979). Reports elaborated on knowledge transfer throughout each collaboration project along with the process phases exposing the role of different mechanisms of social integration. Taking the theoretical background into account, the within-case analysis revealed details of how learning is facilitated (ibid.). Accordingly, this analysis generated an overview of the systematic and incidental mechanisms of social integration used in the management of technological distance. Whenever social aspects such as personal interaction, communication, common activities, events and other relational aspects emerged, they were highlighted as social integration. The resulting variation of mechanisms was aggregated into four distinct mechanisms comprising internal connectedness, external connectedness, systematic communication and socialization. Finally, we performed a

cross-case analysis (Eisenhardt and Graebner 2007) to search for patterns and differences across the cases. We used "pattern-matching logic" (Miles and Huberman 1994; Pauwels and Matthyssens 2004) to further iterate between theory and data. By contrasting the case reports in which the organizations' activities resulted in successful learning outcomes and limited learning outcomes, elaborated on the basis of reaching project goals by fully absorbing the distant knowledge. The data revealed differences in the dimensions of social integration mechanisms involved. The results table (see "Appendix") shows the comparative data and the constructs emerging from this research (Eisenhardt and Graebner 2007). The following section is a detailed description of some of the project cases that represent exemplary results of the data analysis. It distinguishes between the different types of social integration mechanisms which resulted in both limited and successful learning outcomes.

4 Results

4.1 Social integration mechanisms in internal and external collaborations

The results of our data analysis provide a substantial basis for understanding and explaining how firms apply different internal and external[2] absorptive capacity routines to manage technological distance in both internal and external collaboration. More specifically, our analysis focused on the extent and interplay of social integration mechanisms with respect to learning outcome. In Table 2, exemplary cases with limited success and success in terms of comprehensive knowledge absorption were contrasted in order to illustrate differences in the social integration mechanisms. As a result of the cross-case analysis, the mechanisms that constituted the difference between the two cases and their success and limited success are marked with an 'X'. The associated social integration mechanisms that determined the differences are also shown in the Appendix (see "Appendix" for a detailed overview of social integration mechanisms).

From our data, we concluded four types of social integration mechanisms, alone or in combination, determine a project team's ability to transfer and adapt distant knowledge: *Internal connectedness* prevents project teams from locking out alternative technologies by facilitating the transfer of product-related technology between industries and by promoting acceptance and use of foreign[3] knowledge introduced by peers.

It refers to the relationships individuals of the focal project team (as the entity under examination) establish through frequent interaction (Tsai 2001) to internal partners such as internal experts that are in the same organization but are not part of the actual project. This strengthens and facilitates trust and, over time, fosters effective processing external knowledge (Granovetter 1973; Rowley et al. 2000; Uzzi 1996, 1997). Thus, connectedness is therefore is not a binary status but rather a scale depending e.g. how much the partners

[2] Reminder: In the context of the study, internal partners refers to different project teams or team members within the same organization but not involved in the focal project or innovation activity itself, accordingly internal to the organization but not as part of the focal project team. External partners refer on the other hand to any team or actor outside the focal organization that is included or addressed during collaboration. Accordingly internal routines refer to routines, e.g. weekly meetings, with internal partners whereas external routines refer to routines, e.g. newsletters, with external partners (Lewin et al. 2011).

[3] The term foreign knowledge in this context refers to knowledge which originates from outside the respective focal organization and industry and therefore is foreign to the project team and its members (Enkel and Heil 2014; Shan et al. 1994).

Table 1 Project overview and primary data collection for multiple case study analysis

Project	Position of interviewee(s)	Primary data sources[a]	Industry of business unit in charge of project	Industry of innovation partner	Project type
AutoFilm	Project Manager ITM	Phone interview	Automotive	Film	External
AutoFood1	Head of ITM	Phone interview	Automotive	Food	Internal
AutoFood2	Project Manager R&D	Phone interview	Automotive	Food	Internal
AutoInfo	Managing Director (BU) Head of Development	Phone interview Phone interview	Automotive	ICT	External
AutoMed1	Project Manager R&D	Phone interview	Automotive	Medical	External
AutoMed2	Project Manager R&D	Phone interview	Automotive	Medical	External
AutoPipe	Project Manager IM	Phone interview	Automotive	Pipeline	External
AutoPublic	Project Manager ITM	Face-to-face interview	Automotive	Public mngt.	External
AutoText1	Project Manager R&D	Face-to-face interview	Automotive	Textile	External
AutoText2	Head of ITM	Phone interview	Automotive	Textile	External
AutoText3	Head of ITM	Face-to-face interview	Automotive	Textile	External
AutoTurb	Project Manager R&D Project Manager R&D	Phone interview Phone interview	Automotive	Turbine	External
AutoTele	Project Manager ITM	Face-to-face interview	Automotive	ICT	External
AutoWind	Project Manager R&D	Phone interview	Automotive	Wind energy	External
IndustAuto	Head of Advanced Engineering	Face-to-face interview	Industrial drives	Automotive	Internal
MechAero	Managing Director (BU) Head of Development Project Manager R&D	Face-to-face interview Face-to-face interview Face-to-face interview	Mechanical engineering	Aerospace	External
MechAuto1	Managing Director (PL)	Phone interview	Mechanical engineering	Automotive	Internal & external
MechAuto2	Head of IT	Phone interview	Mechanical engineering	Automotive	Internal
MechAuto3	Project Manager ITM	Phone interview	Mechanical engineering	Automotive	External
MechAuto4	Project Manager ITM Project Manager R&D	Face-to-face interview Face-to-face interview	Mechanical engineering	Automotive	External

Table 1 continued

Project	Position of interviewee(s)	Primary data sources[a]	Industry of business unit in charge of project	Industry of innovation partner	Project type
MechTurb	Head of Technology Foresight	Face-to-face interview	Mechanical engineering	Turbine	External
MechWind	Head of Business Development	Phone interview	Mechanical engineering	Wind energy	External
MinAuto	Project Manager R&D	Face-to-face interview	Mining	Automotive	Internal
MinChem1	Head of New Business	Face-to-face interview	Mining	Chemical	Internal
MinChem2	Head of Application and Basic Research	Face-to-face interview	Mining	Chemical	External
ConRace	Head of New Business Project Manager New Business	Phone interview Phone interview	Container	Racing	Internal & External

Cases of limited learning outcome indicated by gray background

ITM Innovation and Technology Management, *BU* Business Unit, *PL* Product Line, *ICT* Information and Communication Technology

[a] Respondents' final approval and on-site workshops with project members from the business units in charge of the projects provided additional validation of the results

trust one another (Ebers and Maurer 2014). This also applies to *external connectedness*, i.e. the strength of the relationship to a partner outside the focal organization. External connectedness increases a project's capacity to translate and leverage the newly absorbed knowledge, especially in the process technology dimension, by incorporating it into a firm's existing knowledge base. *Systematic communication* refers to the timing, channel, breath of communication among the project team and its internal and external partners (Chen and Paulraj 2004). It proves to be a particularly good catalytic converter by building bridges and providing complementarities between internal and external absorptive capacity routines to overcome technological distance. Finally, *socialization* acts as an umbrella mechanism for internal and external connectedness, primarily supporting knowledge transfer at all phases of internal and external absorptive capacity routines, both within and between firms. At the same time, it becomes clear that socialization with either the internal or the external partners can lead to more trust and hence a stronger connectedness to those partners. In the sections below we explain new and refine existing social integration mechanisms to identify usage and quality patterns.

4.2 Internal connectedness

In a product-related technological context in particular, we found that internal connectedness fosters internal absorptive capacity routines and ensures horizontal inbound social integration. This enables companies to identify valuable foreign (product) technology and

Table 2 Illustration of limited and successful learning outcomes and the associated social integration mechanisms

AC	Learning outcome		SIM			
	Limited	Successful	IC	EC	SC	SOC
Explorative learning phase	#Project AutoFilm: exploration of foreign technology not sustained due to failure to propagate new knowledge	#Project AutoPublic: exploration of foreign knowledge thanks to internal support for new technology	×		×	×
	#Project MechAuto4: limited exploration of foreign technology due to adherence to originally-defined resources	#Project MechAero: extensive exploration of foreign knowledge thanks to CEO's support of new technological opportunity	×	×	×	
	#Project AutoTele: limited exploration of foreign knowledge due to failure to approach collaborating partner	#Project AutoText3: extensive exploration of foreign technology thanks to systematic specification of problems and good communication with partners	×	×	×	×
	#Project AutoMed2: limited learning as poorly prepared foreign technology failed to find additional partners	#Project MechAuto3: exploration of foreign technology thanks to comprehensive specification of technology which reduced distance to partner	×	×		×
	#Project ConRace: limited explorative learning due to lack of opportunities to support of foreign technology	#Project MinAuto: comprehensive exploration of foreign technology thanks to opportunities to personally exchange knowledge	×		×	×
Transformative learning phase	#Project MinChem1: insufficient knowledge transformation due to failure to consider all mandatory foreign industry norms	#Project AutoFood1: extensive transformation of technology from foreign industry thanks to interdisciplinary team structure	×		×	×
	#Project AutoWind: unplanned stoppage of knowledge transformation before relevant foreign technical knowledge such as assembly requirements could be completely incorporated	#Project MechTurb: comprehensive transformation of knowledge thanks to the provision of relevant information to partners and their integration in major decisions	×	×	×	×
	#Project AutoFilm: limited knowledge transformation due to lack of opportunities to explain foreign technology in detail	#Project AutoInfo: extensive transformation of foreign technology thanks to efforts to interact and overcome knowledge distance	×	×	×	×
	#Project AutoText2: no knowledge transformation due to lack of data about foreign technology	#project AutoText1: extensive knowledge transformation thanks to manager being solely in charge of foreign technology	×	×	×	×

Table 2 Illustration of limited and successful learning outcomes and the associated social integration mechanisms

AC	Learning outcome		SIM			
	Limited	Successful	IC	EC	SC	SOC
	#Project AutoTele: limited knowledge transformation due to management's objection of foreign technology	#Project AutoFood2: extensive knowledge transformation thanks to business case specially created for foreign industry and inclusion of pilot customer	×		×	×
	#Project MechAuto4: limited knowledge transformation due to restrictions on collaboration partners	#Project IndustAuto: comprehensive knowledge transformation thanks to integration of additional partners to overcome technological challenges	×		×	×
	#Project AutoMed2: limited transformative learning due to lack of information (from partner) about foreign industry requirements	#Project AutoPipe: extensive knowledge transformation thanks to contractual regulation of intensity and frequency of foreign knowledge exchange		×	×	×
Explorative learning phase	#Project MechAuto4: limited exploitative learning due to poorly coordinated exchange of technological details	#Project AutoTurb: extensive exploitation of foreign knowledge thanks to systematic supply of information to partners		×	×	×
	#Project AutoWind: limited exploitative learning due to poor acceptance of partner and foreign technology at the working level	#Project AutoMed1: extensive exploitative learning thanks to benefits of foreign technology and systematic promotion by well-known key customer	×	×	×	×
	#Project MinChem1: insufficient knowledge exploitation due to poor explanation of benefit of foreign technology	#Project MechAuto1: exploitation of knowledge thanks to promotion of foreign technology in corporate communications	×	×	×	×
	#Project MechWind: limited exploitation of foreign technology due to lack of systematic documentation of foreign knowledge	#Project MinChem2: extensive exploitation thanks to documentation of foreign technology and motivation to assimilate it—this was the impulse for the project		×	×	×

AC absorptive capacity phase, *SIM* social integration mechanisms, *IC* internal connectedness, *EC* external connectedness, *SC* systematic communication, *Soc* socialization

bridge it to internal demands and conditions, thereby concurring with existing research (Huber 1991; Tsai 2001), which states that before a new product idea or product-related foreign technology can be applied, it must be adapted to the innovation strategy of the company. And in doing so, take into account the abilities and competences of the project team and its internal partners (Bakker et al. 2011). The newly acquired external knowledge also needs to be transformed to a level suitable for use by the internal actors (Uzzi 1997)

and hence requires the exchange of relevant knowledge between employees (Spender 1996).

Accordingly, in the case of the MinChem2 project, the product idea originated from the automation division's head of sales. He knew from his experience in sales that customers were looking for a more reliable and cost-efficient cooling system for trains. He shared this insight with a colleague from the mining division of a company where he used to work.

> The impulse for the project actually originated from [the] sales [department], they told us about customer (…) repeatedly asking for a highly efficient cooling system. This is how we knew about a new opportunity for our [mining] technology in a new industry. (Head of Application and Basic Research)

Our data suggests that this employee would not normally have learned about this need for a new technological solution in a foreign industry. Only because the internal partner shared this knowledge was he able to identify external knowledge and, equally importantly, trust the value of this foreign knowledge. Connectedness to such internal partners, even if they work in another division or business unit, not only facilitates identification of new external product technology, but also improves acceptance of externally acquired ideas and, as in the case of the MinChem2, of externally identified technological needs valuable to a firm. In a contrasting case, the aim of the internal collaboration in the MinChem1 project was to transfer existing mining pump technology to a new technological (product) application in the chemical industry, an industry which was foreign to the project team. The mining division project team chose the water technology division as an internal partner because of its previous experience in the chemical industry. Despite collaborating with an internal partner, the division was unable to transform the technology to the foreign industry because it was unable to fulfill one of the industry's mandatory norms. The data revealed that the project team was poorly connected with its colleagues in the water technology division. It therefore lacked access to some important information because it was excluded from parts of the development process. Hence it was unable to fulfill an industry norm relevant to the new technological application. The project team failed to create the internal connectedness needed to communicate across different channels and exchange difficult-to-transfer knowledge.

The case of the AutoPublic project on the other hand illustrates an employee who found a promising technological solution to a production process problem in the public sector. The challenge faced by his department was connected the logistics of with goods sorting. As the required technology originated from the public sector, a field outside of his firm's established industry boundaries, he searched for an internal partner willing to accept the foreign approach and adapt the technological solution to the internal setting. Our data suggests that the employee partnered with a colleague from his own internal network which allowed him to successfully transform and incorporate the foreign technology. The personal relatedness between the collaborating partners meant they trusted each other's expertise which enabled them to extensively exchange rich information. Our data reveals that internal connectedness facilitates acceptance of unconventional technological approaches as the trust which develops over time between employees fosters mutual understanding.

Corroborated by theory (Ebers and Maurer 2014; Schoorman et al. 2007), our results suggest that strong internal connectedness promotes common understanding of problems. Further, the results support literature stating that internal connectedness based on trust (Gulati 1995; Petruzzelli 2011; Smith et al. 2005) is a particularly valuable way to increase technological proximity between collaborating partners. Internal connectedness based on

frequent communication leads to more effective interactions (Levin and Cross 2004; Reagans and McEvily 2003; Uzzi 1997) thus enable collaborating partners to reduce technological distance. The trust partners have in one another's expertise increases their initial willingness to accept foreign product-related technology as emotional involvement motivates actors to try and understand the needs of their partner (Granovetter 1985). Subsequently, internal connectedness and the expectation of further collaborations catalyze the development of cooperative norms supporting socialization and encouraging actors to bridge the knowledge gap.

4.3 External connectedness

Firms engaging in frequent interactions with potential external knowledge providers are better connected with and closer to those external partners (Granovetter 1985). Our data illustrates that external connectedness ensures horizontal outbound social integration which makes it easier for firms to process foreign technology and new knowledge. We found that external connectedness is especially beneficial to the exchange of the process-related foreign technology as it helps actors in order to overcome distance at this level. Although development of a new technology with distant knowledge requires extensive research efforts, intense collaboration with external partners has been shown to shorten project times. This relates to previous research which argues that a company strongly connected with its external partners is more open to exploring, transforming and exploiting foreign knowledge (Hansen, et al. 2001; Kalogerakis et al. 2010; Maurer et al. 2011; Uzzi and Lancaster 2003). This, in turn, improves the reliability and quality of the transferred knowledge (Fischer et al. 2002).

The MechAuto1 project is an excellent example of a project benefiting from such collaboration even though the external partner had no established knowledge in the foreign industry, which in this case was the wheel hub industry. The project team had developed a new solution for electronic drives but the technological approach was not established in the automotive industry and would require changes to the vehicle architecture. The team decided to look for an external development partner to help apply the new technology. The partner had to be open to a change of strategy and prepared to invest heavily in new vehicle designs, despite having no technological knowledge or experience of the new electronic drive. The choice fell on an external partner they'd previously worked with during a public organization research project. It was this project that gave the project team experience of collaborating with the external partner in a foreign industry. They were confident they would understand the distant technology as they knew they could refer to the partner's knowledge. Our data shows that the connectedness created during the few months of collaboration enabled the project team to trust and rely on their external partner. They also learned how the external partner's open innovation culture and open-mindedness toward collaboration across industry boundaries generated much potential for radical innovation. Thus, both partners were motivated not only to exchange distant knowledge about the new technology, but also to discuss data, including sensitive data, in more detail.

As stated earlier, collaboration with an external partner in a foreign industry involves overcoming knowledge distance in the context of product- and process-related technology (Nooteboom et al. 2007). In the case of the AutoWind project, the project team from the automotive industry wanted to transfer inverter technology to an analogue domain. In their search for new business, they looked for potential partners in foreign industries who could make use of the technology. The project team management identified an external partner in the wind industry. The management of the external partner agreed to the collaboration. The

project team's goal was to gain a better understanding of the wind industry and its specific requirements, while the external partner's goal was to learn about the inverter technology. However, the transformation of the inverter technology to the requirements of the wind industry was stopped before it was completed. Our data suggests that management failed to pay sufficient attention to the integration of the external partner's staff. Accordingly they received little information about the purpose of the collaboration. Fearing job losses as a result of the collaboration, the external partner's staff refused to attend meetings or participate in any interactions involving the exchange of knowledge. As a result, they failed to connect with the project team. Neither did the external partner's staff provide the requested information about industry norms needed by the project team to overcome their knowledge distance and properly transfer the inverter technology to the requirements of the wind industry. The AutoWind project failed to create opportunities to generate and exchange new technological and external knowledge. The project team was prevented from obtaining more precise information which would have helped them to overcome the technological distance. Of more importance than the missing management support, was the inability of the project team to create connectedness with their partner. The case is one example how external connectedness can be highly valuable for a project team. The project team of case AutoWind could not benefit from the positive effect that external connectedness has on knowledge transfer between partners, i.e. its positive effect on the efficiency with which connected partners are able to process technology, especially foreign technology (Uzzi 1997).

As a case in contrast, the AutoInfo project illustrates how a project team can benefit from strong external connectedness. The project initiator, who came from the industrial drive sector, met his future external partner, who worked in the ICT sector, at an IT congress workshop. They were on the same team at the workshop and immediately connected with each other as they shared a common interest in service-based business opportunities.

> I met [my external partner] at a congress and we immediately found out about our common interest. The enthusiasm we both shared let us become partners and ever since we have stayed in touch. At the beginning, the partner probably hoped to generate new business, but even though their hardware is not part of our system, [the partner] supported us all through development and we still exchange technological knowledge and ideas today. (Managing Director Business Unit 'Info')

Our data reveals that, in this case, trust and mutual understanding were the result of an interest in another field. The resulting connectedness enabled the external partner to transfer a new idea to his ICT industry, even though his industry setting was distant from the industrial drive sector. Furthermore, our data implies that such strong external connectedness was only possible because the partners had met at a congress and shared a common interest. This enabled them to convince their respective managers to support a collaboration to develop a new technological solution for a service concept in the driveline technology sector. The process-related technology originated from the ICT industry. Thanks to the partners sharing all relevant information in an effort to overcome their knowledge distance, it was possible to transform and exploit this technology. The partners met on a weekly basis to ensure the foreign knowledge was correctly understood.

All of the project cases described above show how external connectedness supports routines, enabling firms to acquire new knowledge across established industry boundaries. As literature constitutes, prior connectedness promotes trust between collaborating partners and makes it easier for project teams to process and apply technological knowledge

relevant to the full implementation of novel solutions (Ebers and Maurer 2014; Zollo, et al. 2002). Furthermore corresponding routines are likely to extend with time (Elkjaer 2003; Gulati 1995). Our data, however, indicates variations in the strength and success of such external connectedness. If collaborating partners have strong connectedness, this reduces the effort required to communicate and transfer knowledge. Proximity is also expected to result in more frequent interactions between internal and external team members (Bercovitz and Feldman 2011) which also illustrates how internal and external connectedness can mutually influence each other. Our data analysis showed that the strength of external connectedness also affects a project team's ability to overcome distance, especially in process-related technology: The stronger the connectedness, the greater the willingness of partners to overcome technological distance, and the richer the content of the exchanged knowledge. If connectedness was weak or non-existent, crucial information was less likely to be exchanged and the project was more likely to fail. Consequently, our data indicates that trust in an external partner's expertise and willingness to open up to foreign technology and distant industries determine external connectedness and the success of collaborative innovation.

4.4 Systematic communication

Knowledge transfer is said to depend on the sender, the channel of transmission, the message being transmitted, the receiver and, last but not least, the context of transmission (Szulanski 2000). Our findings show that systematic communication fosters vertical social integration during the explorative, transformative and exploitative phases of learning. Accordingly, systematic communication of the relevant information through the right channel at the right time to the right group of people affects how well distant knowledge or foreign technology is acquired, assimilated and applied.

The case of project AutoText3 illustrates how internal and external absorptive capacity routines foster systematic communication of innovation activities in distant knowledge and technology and link the different phases of a collaborative innovation project. The project team announced an innovation award for ideas for production facilities in the automotive industry. It was particularly looking for ideas outside of its established industry boundaries. The project team had previous experience of searching for radical ideas and new technology in foreign industries. The award was announced internally on the intranet and externally on the Internet. It was open to anyone in Germany with new ideas on improving production and as not restricted to technology in the automotive industry. More than 150 ideas from different industries were submitted and the project team invited eight of the submitters to participate in further collaboration. The eight finalists were announced in press releases and the company newsletter, together with their ideas, underlying technologies and why they'd been chosen. By communicating the ideas in this manner, internal specialists from different technologies and industries were able to come forward and discuss the ideas with the eight finalists.

> At first, we didn't share the content of the ideas very broadly. We did not want to run the danger of other people stealing them. Only when we decided to promote the ideas and the associated technological possibilities through various [internal and external] communication channels, were we able to become a sort of innovation hub. For potential partners, both internal and external, we became aware of our strategy to search for valuable new technology in all industries. (Head of Technology Development)

The end result was that the project team learned how to manage technological distance and was able to transform an idea from the textile industry into a technological solution for the automotive industry. Collaboration with the external partner was communicated via different external channels (Internet, press releases, exhibitions), and the progress of the project and technology integration were systematically communicated via internal channels (intranet, newsletter, internal technology blog). These communications were not only intended to provide information about the status of the project and the new external ideas, but also to create external awareness of the project team's openness to external knowledge and foreign technologies, and to provide information about the fields in which the project team might be interested in collaborating in in the future. Internally, the project team sought to document new knowledge to enable others to make use of the valuable foreign technology. They also wanted to promote openness toward foreign industry and demonstrate how external knowledge fosters diverse technological competencies.

Complementary internal and external mechanisms of systematic communication and the corresponding internal and external absorptive capacity routines ensure that internal and external partners are equally informed (Christensen and Cornelissen 2011). The data illustrate that the corresponding internal and external activities were synchronized in such a manner throughout the entire collaboration, e.g. in the AutoText3 project, so that the project team was able to efficiently identify, transform and incorporate the foreign technology of the textile industry. Above all, our data implies that systematic communication and the learning outcomes of successful projects often have long-term benefits for the future management of technological distance. In this project case, systematic communication increased the participation of external partners from foreign industries by making them aware of the aware and showing them how open the project team was to collaboration with a foreign industry. In addition, internal communication of the success story also reduced so-called "not-invented-here" attitudes (Katz and Allen 1982) which often result from collaborations with external partner in distant industries.

The case of the AutoPipe project is another example of how the internal and external mechanisms of systematic communication are mutually beneficial in situations requiring the management of knowledge distance. The project team's goal here was to develop a sealing technology for roller bearings in the automotive industry. It sought cooperation with external partners to find an external technology which could be transferred and applied to the automotive industry. Initially, they were unable to find a suitable technology for developing a new solution. They systematically communicated the project and its challenges internally (e.g., in the company's newsletter and intranet) and externally (e.g., at a congress, on the Internet and in trade magazines). Our data shows that the idea to look for an external partner in the pipeline industry came from an employee who wasn't working on the project at that time, but knew about it from the internal communication (an intranet article). The external partner was able to gather valuable information about the project via the external communications (e.g. a press release and the Internet) and hence understood the goal of the project despite it being in a foreign industry. The external partner, who was open to collaboration with the project team, was able to use this information to bridge his knowledge distance to the problem statement. He was also able to directly provide a technological solution, although his knowledge was based in the context of a distant industry. The externally communicated project information helped to bridge the technological distance to the original problem statement and its challenges. The external partner was immediately able to provide the required roller bearing technology. In this case, the internal and external mechanisms of systematic communication were complementary as they harmonized in content and context, thereby reinforcing and fostering each other. The

data thereby illustrates a further benefit of systematic communication with internal and external partners. Thus, by learning about collaboration efforts through different communication activities, actors can better relate to existing knowledge.

In line with previous research (Christensen and Cornelissen 2011, Milgrom et al. 1991), our study shows that it is easier to manage collaborations with partners with a distant knowledge context or in a foreign industry if new knowledge is systematically communicated to internal and external actors. Systematic communication not only supports the vertical integration of the three phases of absorptive capacity, but also links internal and external absorptive capacity routines by creating a common knowledge base for all partners. In this way, systematic communication is the first step to reduce technological distance between the collaborating partners and at the same time reinforces and links internal and external connectedness. Moreover, our data illustrates how systematic communication makes it easier for internal and external partners to refer back to information. This is important as it creates feedback loops which facilitate the management of technological distance.

4.5 Socialization

Mechanisms of socialization are responsible for more open and coincidental interaction and the flow of information in personal communication (Adler and Kwon 2002; Lewin et al. 2011). Socialization introduces an organization-specific language making it easier for new actors to understand background information and interact with other members of the organization (Hansen 1999; Johnson, et al. 1994). Our findings reveal how recombining new and existing knowledge among partners was encouraged through comprehensive social interaction and time spent together led to common project goals and a common understanding of what knowledge is needed by the other.

The AutoText1 project case is an interesting example of how socialization mechanisms are able to create connectedness with internal and external partners to help actors reduce their knowledge distance. The project team, who was based in the automotive industry, wanted to find a technological solution for lightweight products to reduce the fuel consumption of future vehicles and hence meet stricter pollution controls. As the intention was to find a technological solution originating from the textile industry rather than from the automotive industry, a project team leader was selected who'd previously worked at an institute specializing in fiber-reinforced material technology. The project leader attended several internal events to promote the foreign technology among internal partners. These events not only gave him the opportunity to present the technology and project in a plenum, but also to comprehensively socialize with colleagues.

> The technology is new and really different from what [our firm] usually does, and this is why I took every chance to talk to my peers in a personal, more informal surrounding. For them, it took the pressure off of giving an official statement. For me, it helped me to explain the new approach and, at the same time, I was often able to inspire my counterpart. (Project Manager Corporate Research and Development)

Our data suggests that informal interaction with an internal partner in the chassis technology business unit led to an additional project. During a social event, the project leader connected with an internal partner and explained the foreign technology to him in detail. The latter was then able to bridge the technology of textile industry to chassis technology. Our analysis points to the insight that, through socialization, partners gain familiarity with one another, develop a mutual understanding of each other's technological

contexts and establish trustful relationships bridging technological distance and resulting in more effective absorptive capacity routines. Similarly, we found that mechanisms of socialization productively link internal and external connectedness. Socialization not only created the ability to share new knowledge with external partners, it also fostered knowledge transfer with internal partners which in turn linked internal and external connectedness and simplified the management of technological distance. The cases also illustrate that socialization, even informal voluntary interactions where partners choose who they associate with, complements systematic communication by directly affecting how foreign knowledge is shared between internal and external partners. Following theoretical lines, our data suggests that socialization enabled the collaborating partners to acquire, transform and apply new knowledge more efficiently (Bercovitz and Feldman 2011; Elkjaer 2003; Hotho et al. 2012) and activities resulting from socialization generate a stronger connection (Liebeskind et al. 1996) between internal and external partners (Ahuja 2000; Bartsch et al. 2013; Hansen 1999; Nahapiet and Ghoshal 1998).

Figure 2 summarizes our findings by illustrating the extent of and interplay between social integration mechanisms in the context of the process phases of absorptive capacity. Systematic communication is presented between the phases of explorative learning, transformative learning and exploitative learning, meaning it enables the focal project team members to go from identifying external knowledge (explorative learning) to assimilating it to its own and specific situation and context (transformative learning) to applying it in the project they are working on (exploitative learning). Based on the provided information at the right time in the right extent to the right project team member the different phases of knowledge absorption are linked together. Connectedness to the collaborating partners (internal as well as external) plays a distinct role in all project phases. Internal connectedness creates a link to internal partners throughout distant collaboration while external connectedness creates a link to external partners in a similar vein. At the same time, systematic communication of a project team influences its connectedness to the internal and external partners. Interaction, providing relevant and important information leads to trust and a stronger relationship, i.e. connectedness. Ultimately, mechanisms of socialization operate in the background throughout the complete project. Any form of addressing

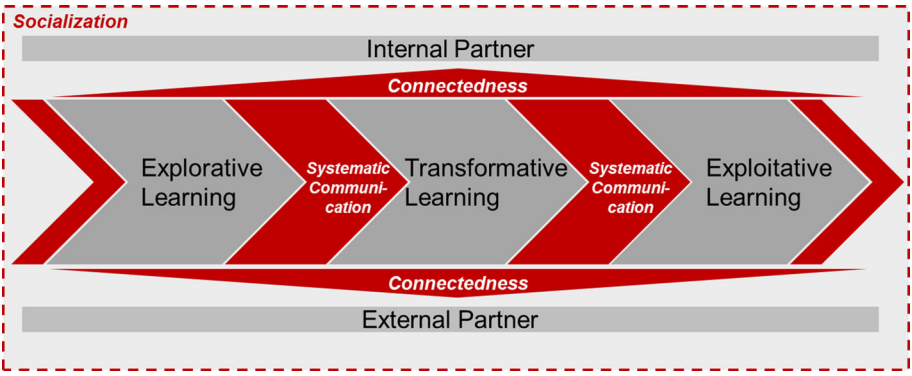

Fig. 2 Social integration mechanisms surrounding internal and external absorptive capacity routines

each other and interacting is part of the socialization process which thus surrounds and facilitates all phases and activities of distant knowledge transfer. Thus, socialization can foster as well as hinder the transfer of distant knowledge.

5 Conclusion

After giving an overview on the results in Tables 2 and 3 in the appendix and elaborating an exemplary set of cases in the results section, we now conclude: This paper has explored how social integration mechanisms facilitate learning in distant collaborations within and across organizational boundaries. While high technological distance can have a positive influence on innovation performance (Gilsing et al. 2008; Nooteboom et al. 2007), project goals can only be achieved if the social integration of project members is improved in terms of coordination and communication (Boschma 2005; Huber 2012). We have drawn on embeddedness and absorptive capacity literature to shed light on how social integration mechanisms translate into different learning outcomes (Granovetter 1985; Uzzi 1997). Our findings suggest that it is not just the scale or extent, but also the diversity and interplay of social integration mechanisms surrounding internal and external absorptive capacity routines that enable project members to engage in the exploration, transformation and exploitation of distant knowledge.

First, our findings complement earlier research on the importance of social integration mechanisms in increasing absorptive capacity (Jansen et al. 2005; Lewin et al. 2011; Todorova and Durisin 2007; Zahra and George 2002). They reveal that strong and trusting internal connectedness between project members within their organization fosters the creation of proximity to distant knowledge in terms of product technology. Furthermore, strong and trusting external connectedness between project team members and external project partners reduces technological distance in terms of process technology. These findings therefore reveal that the internal and external connectedness of project members plays a significant, yet distinct role in distant collaboration at the product and process technology level, thereby refining earlier research on this topic (e.g., Bakker et al. 2011; Granovetter 1985; Reagans and McEvily 2003; Uzzi and Lancaster 2003).

Second, our research highlights the important impact that trusting internal connectedness has on absorptive capacity in distant collaborations. The more intense project members' relations are, the more they are motivated and able to foster external connectedness. This enables them to investigate new, potentially valuable competences to overcome technological distance. Our findings refine the results of Ebers and Maurer (2014) which show how an organization's absorptive capacity is positively influenced by the internal and external relational embeddedness of its boundary spanners. However, this study did not investigate which factors in particular affect internal and external connectedness. We are supplementing existing literature (Ebers and Maurer 2014; Lin 2006) by substantiating how trust can be bridged from external to internal partners through a strongly connected project team, thus creating openness towards external knowledge, providing more flexibility and communication; and reducing the effort required to coordinate, exchange and combine knowledge in distant collaboration.

Third, we extend the Todorova and Durisin's research (2007), who argued that social integration mechanisms transcend all phases of absorptive capacity, by linking systematic communication, as a facilitator of knowledge sharing and mutual understanding, to all three phases of learning: explorative, transformative and exploitative learning. The creation of mutual understanding as an effect of systematic communication follows Todorova and Durisin's (2007) call to study the antecedents of the "absorptive capacity—learning—new absorptive capacity feedback loop" (Lewin Massini and Peeters 2011, p. 82). While no previous study has examined the processes underlying the mutual influence relationships between internal and external absorptive capacity routines (Lewin et al. 2011), our study illustrates that systematic communication is a key link here as it implies that internal and external connectedness mutually influence each another (Ebers and Maurer 2014) and accordingly contributes to literature.

Fourth, by examining the adoption of distant knowledge we not only empirically found that socialization reduces employees' inhibitions to engage in knowledge-related activities, but also that the extent of their informal interaction affects the development of internal and external connectedness. Hence, the more socialization emphasizes connectedness with others, the more extensive the exploration, transformation and exploitation of distant knowledge. We are thereby supplementing existing literature by substantiating that socialization fosters a better pace of dialogue which is a source of mutual understanding (Bartsch et al. 2013; Maurer et al. 2011). We furthermore contribute to the emerging research investigating the claims of Volberda et al. (2010) and Lewin et al. (2011) that the antecedents of absorptive capacity have separate but complementary effects on learning outcomes.

Overall, our findings emphasize the combined effect of social integration mechanisms are conducive, both directly and indirectly, to the development of absorptive capacity (Rivkin 2000, 2001). Social integration mechanisms link "horizontal" and "vertical" knowledge, thereby increasing the breadth and depth of a project team's knowledge base as well as ensuring that the project will be successfully completed. If a firm possesses the mechanisms to initiate collaboration with internal partners, the same mechanisms will be conducive to collaboration with external partners and vice versa. In addition, strong and trusting relationships accelerate the development of cooperative norms, allowing project members to manage other relations more effectively and efficiently (Gulati 1995; Hillebrand and Biemans 2003). Such learning effects thus enable project members with strong and trusting internal connectedness to establish a similar degree of external connectedness, and vice versa (Campbell 1998).

The results of this study have several important implications for managers. Successful adoption of distant knowledge not only requires a certain configuration of absorptive routines, but also social integration mechanisms to foster complementarities between these routines. The acceptance and application of distant knowledge must be actively encouraged and facilitated through, for example, the adoption and promotion of a participatory management style, the reduction of intra- and inter-organizational structural barriers at both the function and industry level, and the development of appropriate communication styles. Impediments such as hierarchical organizational structure and decision processes prevent the emergence of social integration and the flexibility necessary to manage technological distance.

Finally, as far as the generalization of our findings is concerned, our study was subjected to the limitations of qualitative research. Although we have used a combination of different qualitative methods, drawing on survey data, interview data and secondary data to gain a better understanding of the extent and interplay of social integration mechanisms, the relatively small size and scope of the sample means that the findings cannot be generalized. Therefore, as the greatest strength of case study research with respect to delicate and complex phenomena lies in theory building rather than theory testing (Siggelkow 2007), we encourage future quantitative studies to examine the extent to which our findings can be generalized. Furthermore, although the social integration mechanisms identified in this study are best able to explain the differences in learning outcome, it is likely that other factors such as organizational structure also affect social integration (Lewin et al. 2011). We therefore advocate further research on the interplay between identified mechanisms and other factors to gain more insight into the contingencies which enable distant collaboration.

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Appendix

See Table 3.

Table 3 Illustration of limited and successful learning outcomes and their associated social integration mechanisms

Absorptive capacity phase	Learning outcome		Social integration mechanisms			
	Limited	Successful	Internal connectedness	External connectedness	Systematic communication	Socialization
Explorative learning	#Project AutoFilm: exploration of foreign technology not sustained due to failure to propagate new knowledge	#Project AutoPublic: exploration of foreign knowledge thanks to internal support for new technology	Connectedness to transform foreign technology more effectively and efficiently		Communication of project and technological approach to create internal awareness	Regular socialization with internal partner to create mutual trust in each other's experiences
	#Project MechAuto4: limited exploration of foreign technology due to adherence to originally-defined resources	#Project MechAero: extensive exploration of foreign knowledge thanks to CEO's support of new technological opportunity	Connectedness to expand resources	Connectedness to exchange details of and hence exploit foreign technology	Communication of foreign technology to create internal and external awareness	
	#Project AutoTele: limited exploration of foreign knowledge due to failure to approach collaborating partner	#Project AutoText3: extensive exploration of foreign technology thanks to systematic specification of problems and communication with partners	Integration of internal foreign industry experts to manage technological distance and facilitate connectedness	Regular knowledge exchange with potential partners to create connectedness	Communication of initial challenges and targeted approach to find solution in foreign industry	Socialization with all internal and external actors to link activities, create connectedness and facilitate informal feedback
	#Project AutoMed2: limited learning as poorly prepared foreign technology failed to find additional partners	#Project MechAuto3: exploration of foreign technology thanks to comprehensive specification of technology which reduced distance to partner	Connectedness to increase familiarity with foreign technology, and to trust and make use of expertise	Connectedness to identify foreign technology and to deal with potential quality defects		Socialization with external partner to provide opportunities to discuss confidential issues
	#Project ConRace: limited explorative learning due to lack of opportunities to sufficiently support foreign technology	#Project MinAuto: comprehensive exploration of foreign technology thanks to opportunities to personally exchange knowledge	Connectedness to explain foreign technology more effectively and efficiently		Detailed documentation of technology and its transformation to enable partner to use and refer to existing knowledge in feedback loops	Socialization with colleagues to identify value of foreign technology in project

Table 3 continued

Absorptive capacity phase	Learning outcome		Social integration mechanisms			
	Limited	Successful	Internal connectedness	External connectedness	Systematic communication	Socialization
Transformative learning	#Project MinChem1: insufficient knowledge transformation due to failure to consider all mandatory norms of foreign industry	#Project AutoFood1: extensive transformation of technology for foreign industry thanks to interdisciplinary team structure	Integration of partners into core project team to create connectedness and enable them to transform foreign technology more effectively and efficiently		Systematic documentation and communication of new knowledge among team members to ensure all project steps are linked together	Besides official meetings, informal socialization with team members to foster connectedness
	#Project AutoWind: unplanned stoppage of knowledge transformation before relevant foreign technical knowledge such as assembly requirements completely incorporated	#Project MechTurb: comprehensive transformation of knowledge thanks to the provision of relevant information to partners and their integration in major decisions	Connectedness to facilitate extensive exchange of information about foreign technology and create acceptance	Partner involved in decision-making to transform foreign technology to partner's requirements	Structured communication with internal and external actors to increase learning in corresponding internal and external AC routines	Socialization with team members at conference where foreign technology was identified, understanding of functionality and referral to internal starting point
	#Project AutoFilm: limited knowledge transformation due to lack of opportunities to explain details of foreign technology	#Project AutoInfo: extensive transformation of foreign technology thanks to efforts to interact and overcome knowledge distance	Connectedness to promote unconventional approach to and use of foreign technology, and to improve the project budget	Connectedness to transform foreign technology to local setting more effectively and efficiently	Extensive internal and external communication to create project awareness resulting in formation of new business unit	Combining official meetings with social events to discuss details and ask questions in informal setting
	#Project AutoText2: no knowledge transformation due to lack of data on foreign technology	#Project AutoText1: extensive knowledge transformation thanks to manager being solely in charge of foreign technology	Connectedness to facilitate extensive exchange of information about foreign technology and create acceptance	Connectedness to transform foreign technology to local setting more effectively and efficiently	Systematic communication of new knowledge about foreign technology to all relevant internal and external actors	Socialization in an informal setting to motivate internal and external partners

Table 3 continued

Absorptive capacity phase	Learning outcome		Social integration mechanisms			
	Limited	Successful	Internal connectedness	External connectedness	Systematic communication	Socialization
	#Project AutoTele: limited knowledge transformation due to management's objection of foreign technology	#Project AutoFood2: extensive knowledge transformation thanks to specially-created business case for foreign industry and inclusion of pilot customer	Connectedness to facilitate extensive exchange of information about foreign technology and create acceptance		Systematic communication of project successes to enable use of new knowledge in future projects	Socialization with colleagues to identify experts to transform foreign technology
	#Project MechAuto4: limited knowledge transformation due to restrictions on collaboration partners	#Project IndustAuto: comprehensive knowledge transformation thanks to integration of additional partners to overcome technological challenges	Connectedness to increase familiarity with foreign technology, and to trust and make use of expertise		Structured communication with all actors to increase learning in corresponding internal and external AC routines	Socialization with colleagues to identify experts to transform foreign technology
	#Project AutoMed2: limited transformative learning due to lack of information (from partner) about requirements of foreign industry	#Project AutoPipe: extensive knowledge transformation thanks to contractual regulation of intensity and frequency of foreign knowledge exchange		Connectedness fostered spending great time and effort to transform foreign technology to local setting more effectively and efficiently	Systematic communication of new knowledge about foreign technology to all relevant internal and external actors	Socialization with colleagues to identify experts to transform foreign technology
Exploitative learning	#Project MechAuto4: limited exploitative learning due to poorly coordinated exchange of technological details	#Project AutoTurb: extensive exploitation of foreign knowledge thanks to the systematic supply of information to partners		Connectedness to effectively and efficiently exploit foreign technology	Systematic communication of new knowledge about foreign technology to all relevant internal and external actors	Socialization with all internal and external actors to link their activities, create connectedness and facilitate informal feedback

Table 3 continued

Absorptive capacity phase	Learning outcome		Social integration mechanisms			
	Limited	Successful	Internal connectedness	External connectedness	Systematic communication	Socialization
	#Project AutoWind: limited exploitative learning due to poor acceptance of partner and foreign technology at the working level	#Project AutoMed1: extensive exploitative learning thanks to benefits of foreign technology and systematic promotion by well-known key customer	Connectedness to promote unconventional approach to and use of foreign technology	Partner involved in decision-making to transform foreign technology to partner's requirements	Extensive internal and external communication to create project awareness and common knowledge base	Extensive internal and external communication to create project awareness and common knowledge base
	#Project MinChem1: insufficient knowledge exploitation due to poor specification of benefit of foreign technology	#Project MechAuto1: exploitation of knowledge thanks to promotion of foreign technology in corporate communications	Connectedness to reduce distance to partner in foreign industry by enabling illustration of goals and specify collaboration	Connectedness to effectively and efficiently exploit technology in foreign industry setting	Structured communication with internal and external actors to increase learning in corresponding internal and external AC routines	Socialization with all internal and external actors to link their activities, create connectedness and facilitate informal feedback
	#Project MechWind: limited exploitation of foreign technology due to lack of systematic documentation of foreign knowledge	#Project MinChem2: extensive exploitation thanks to documentation of foreign technology and encouragement to assimilate it—this was the trigger for the project		Connectedness to effectively and efficiently transform technology to foreign industry setting	Extensive internal and external communication to create project awareness—this triggered another project	Socialization with colleagues to enable identification of other foreign industries which technology could be transferred to

AC absorptive capacity

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